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(54) **OPTICAL PICKUP ACTUATOR FOR DRIVING AN OBJECTIVE LENS**

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(30) **Foreign Application Priority Data**

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G11B 7/00 (2006.01)

(52) **U.S. Cl.** **369/44.15**; 369/44.22

(58) **Field of Classification Search** .... None
See application file for complete search history.

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(57) **ABSTRACT**

An optical pickup actuator which includes a base, a blade having an objective lens mounted thereon, a plurality of suspensions supporting the blade to be movable with respect to the base and forming an electroconductive path, and a magnetic circuit driving the blade according to a driving signal applied through the respective suspensions. The magnetic circuit includes a magnet fixed to the base, and a fine pattern coil installed on the blade at a position facing the magnet and having a track pattern coil, a focus pattern coil, and a tilt pattern coil independently driven by current applied through the suspensions and providing driving forces in a track direction, a focus direction, and a tilt direction of the blade.

26 Claims, 8 Drawing Sheets

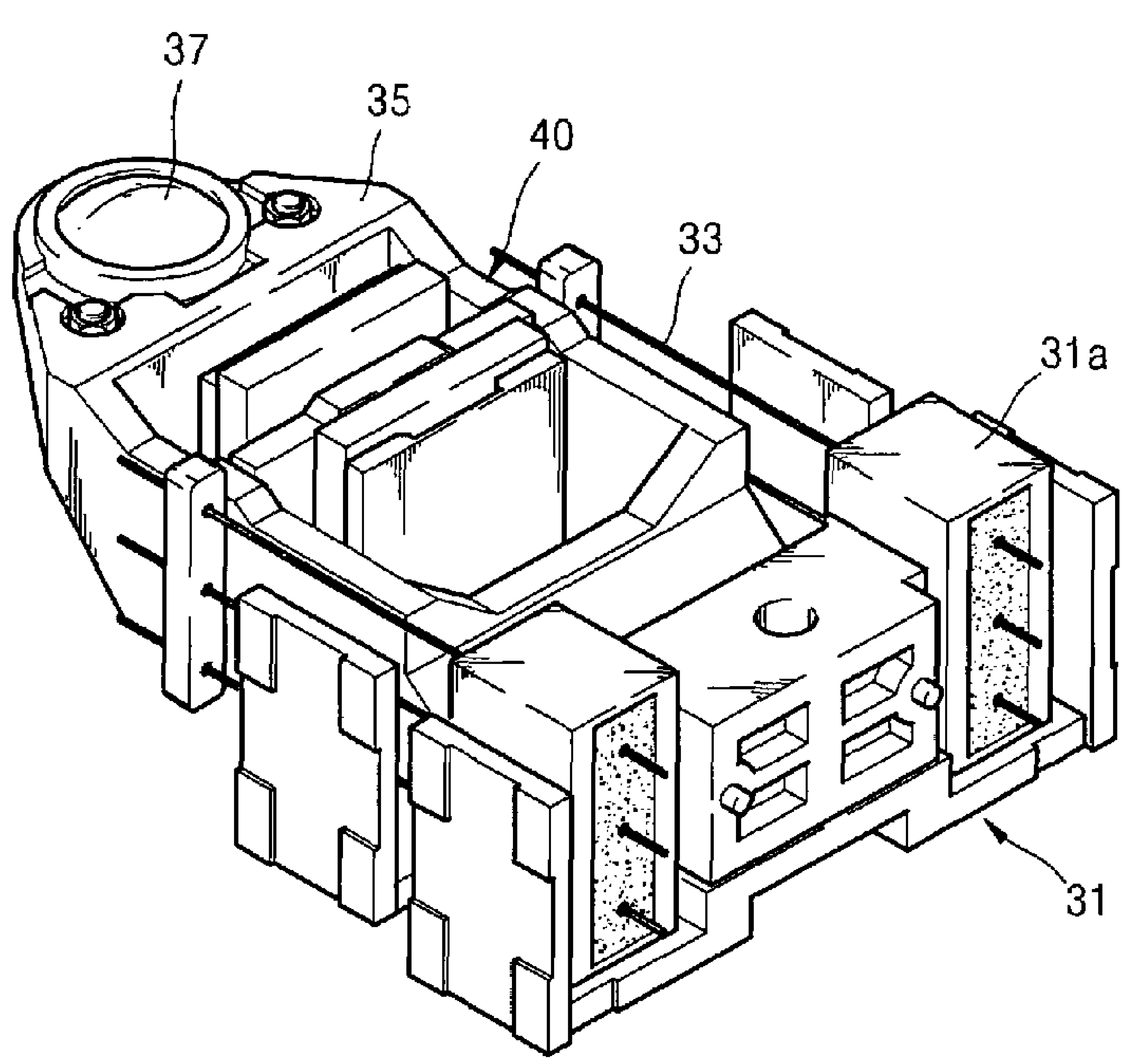


FIG. 1 (PRIOR ART)

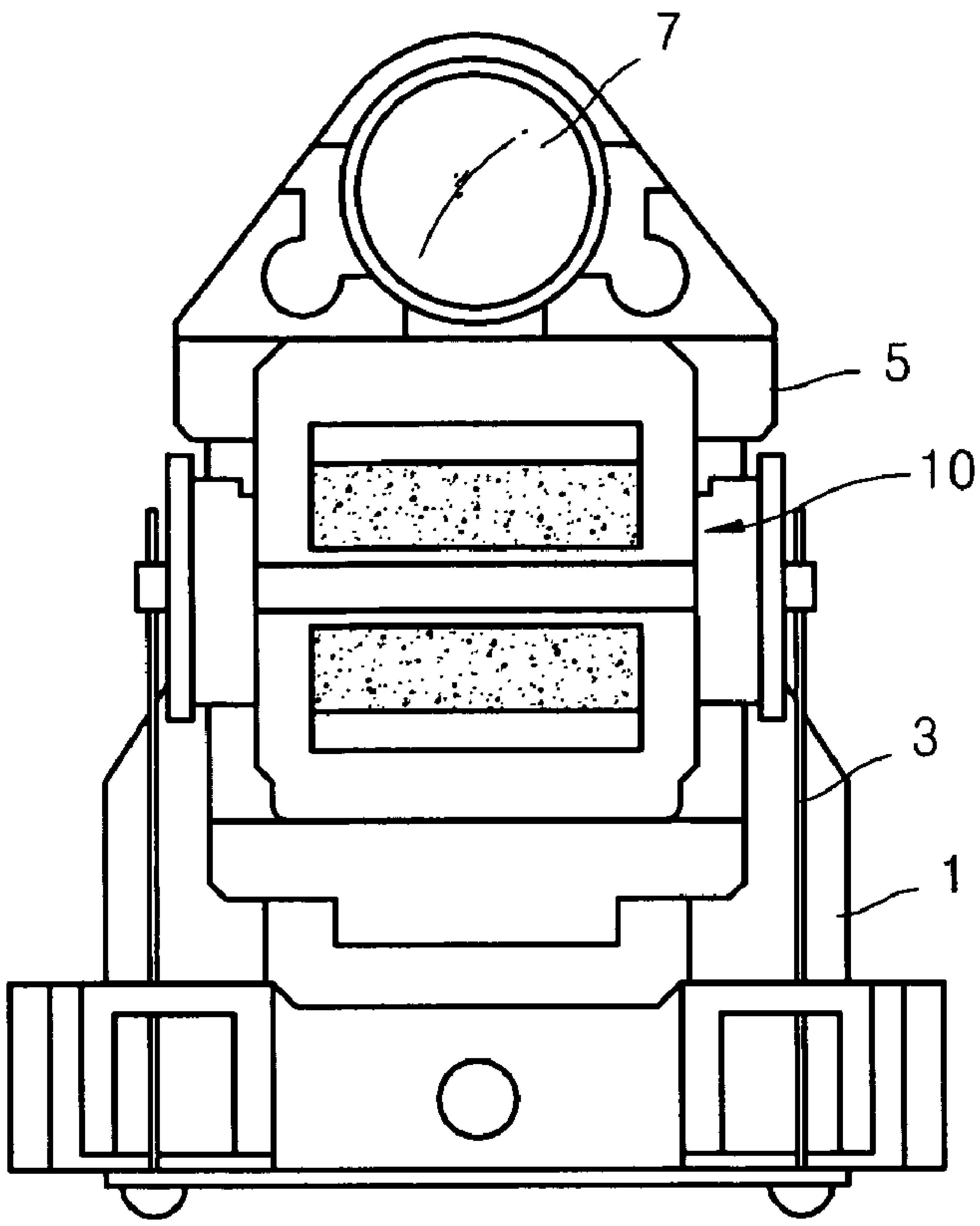


FIG. 2 (PRIOR ART)

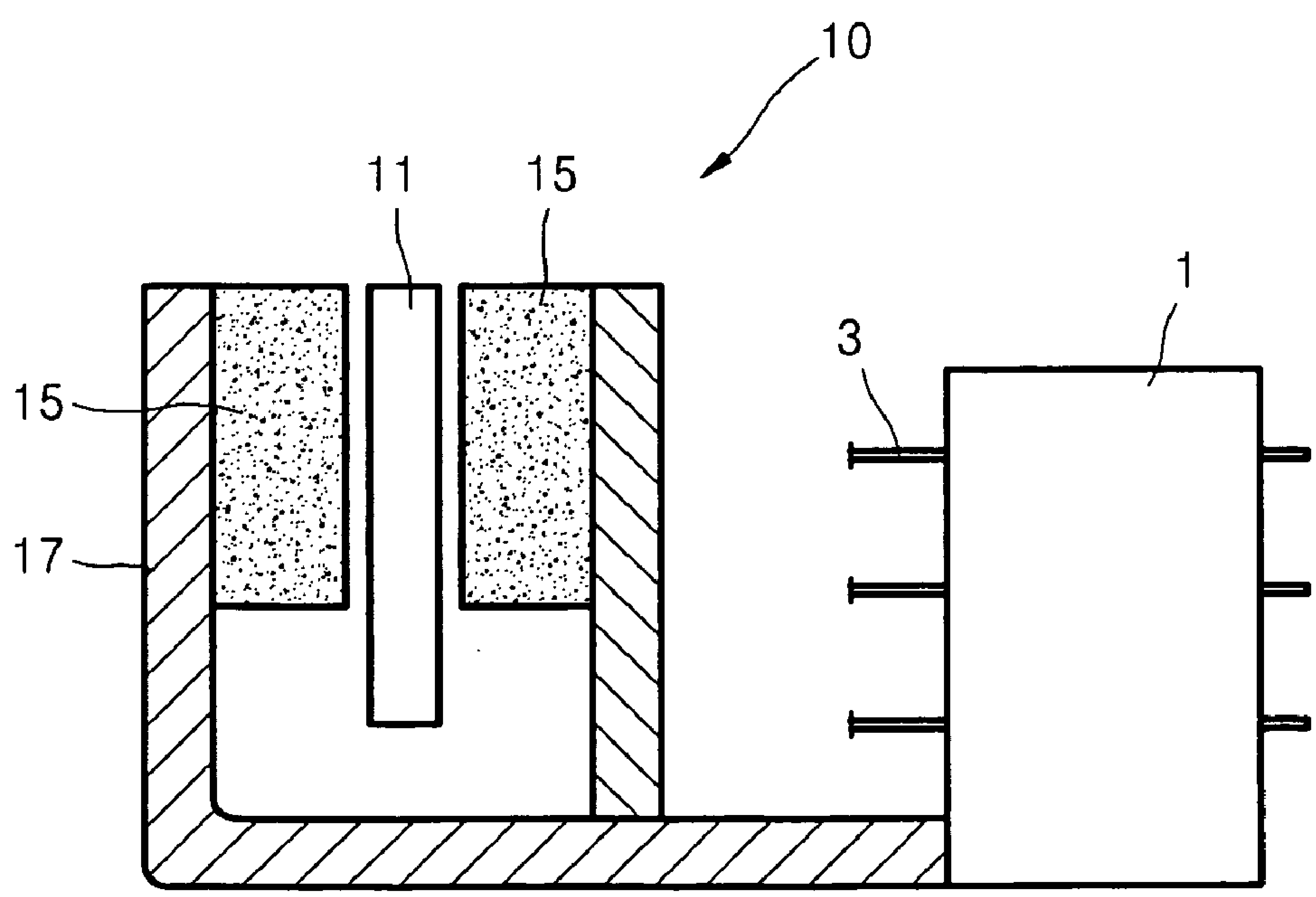


FIG. 3 (PRIOR ART)

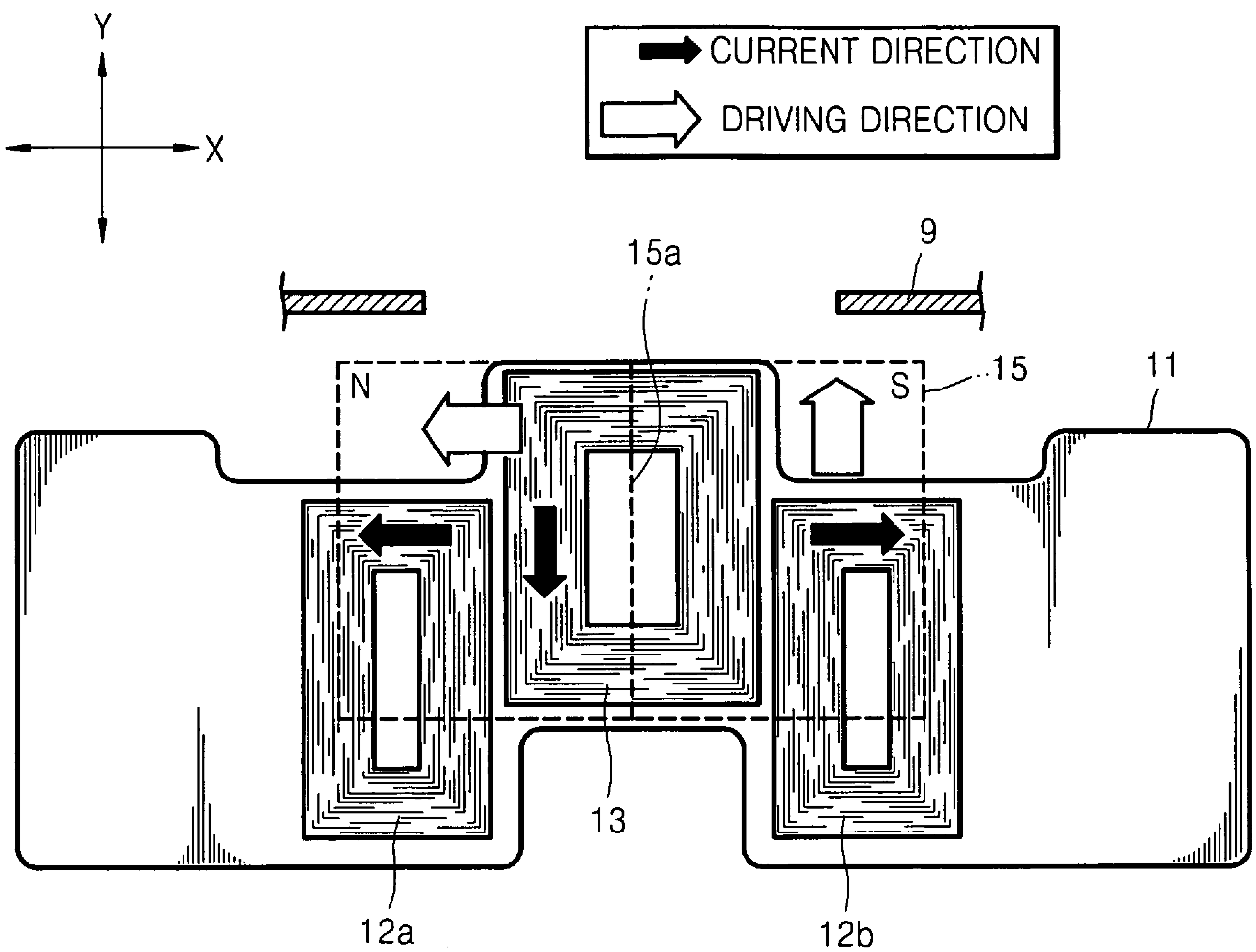


FIG. 4

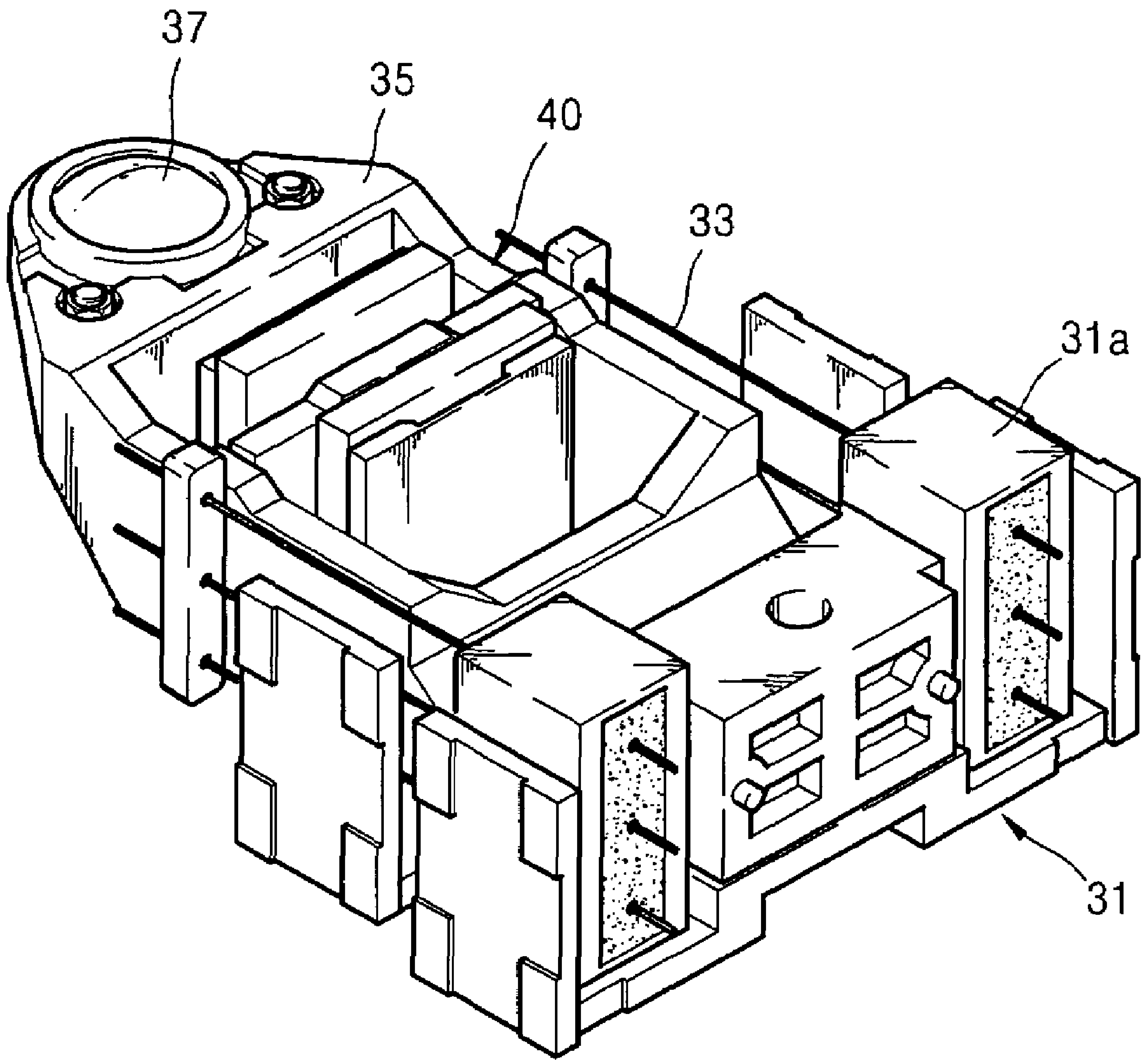


FIG. 5

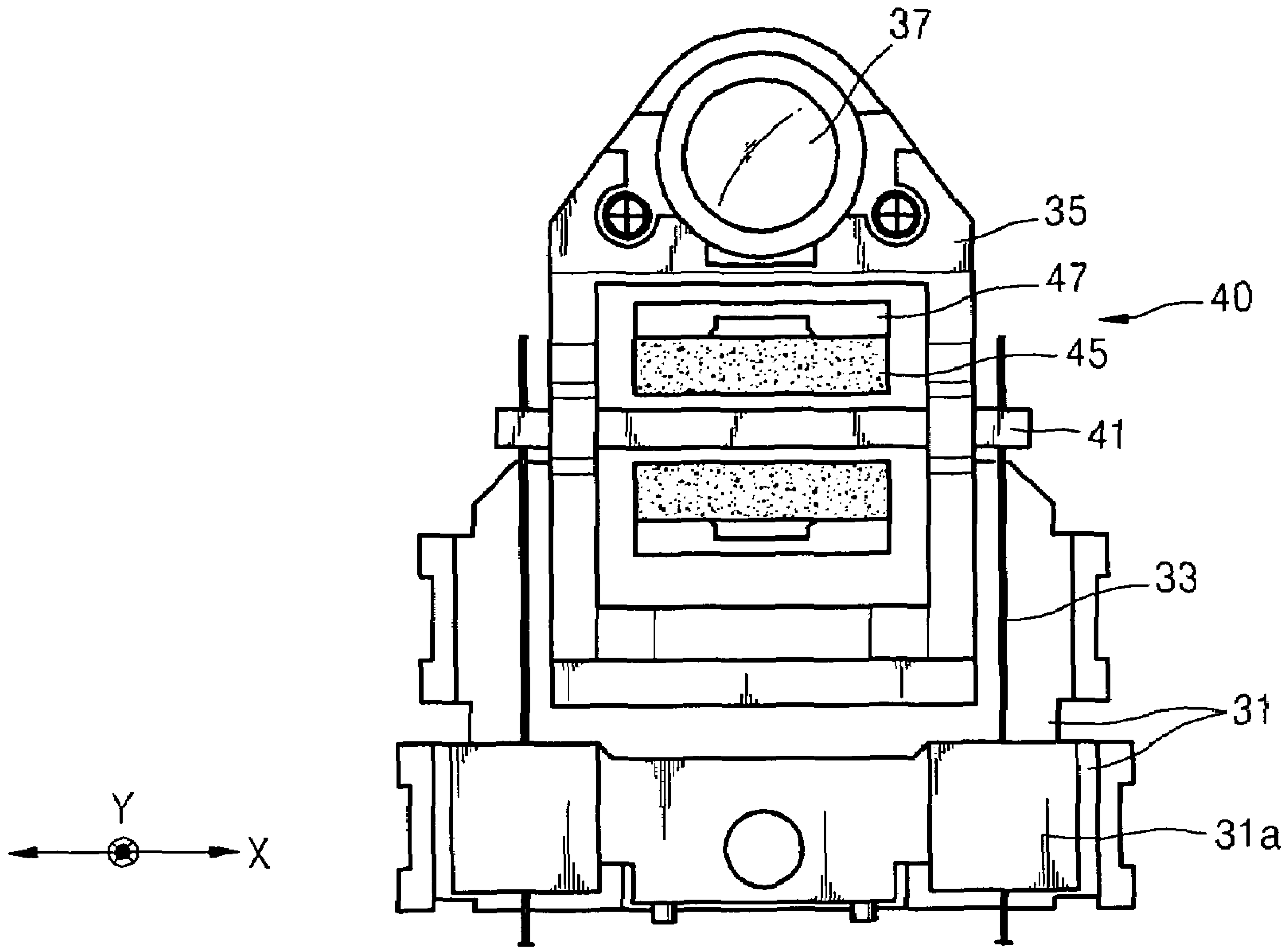


FIG. 6

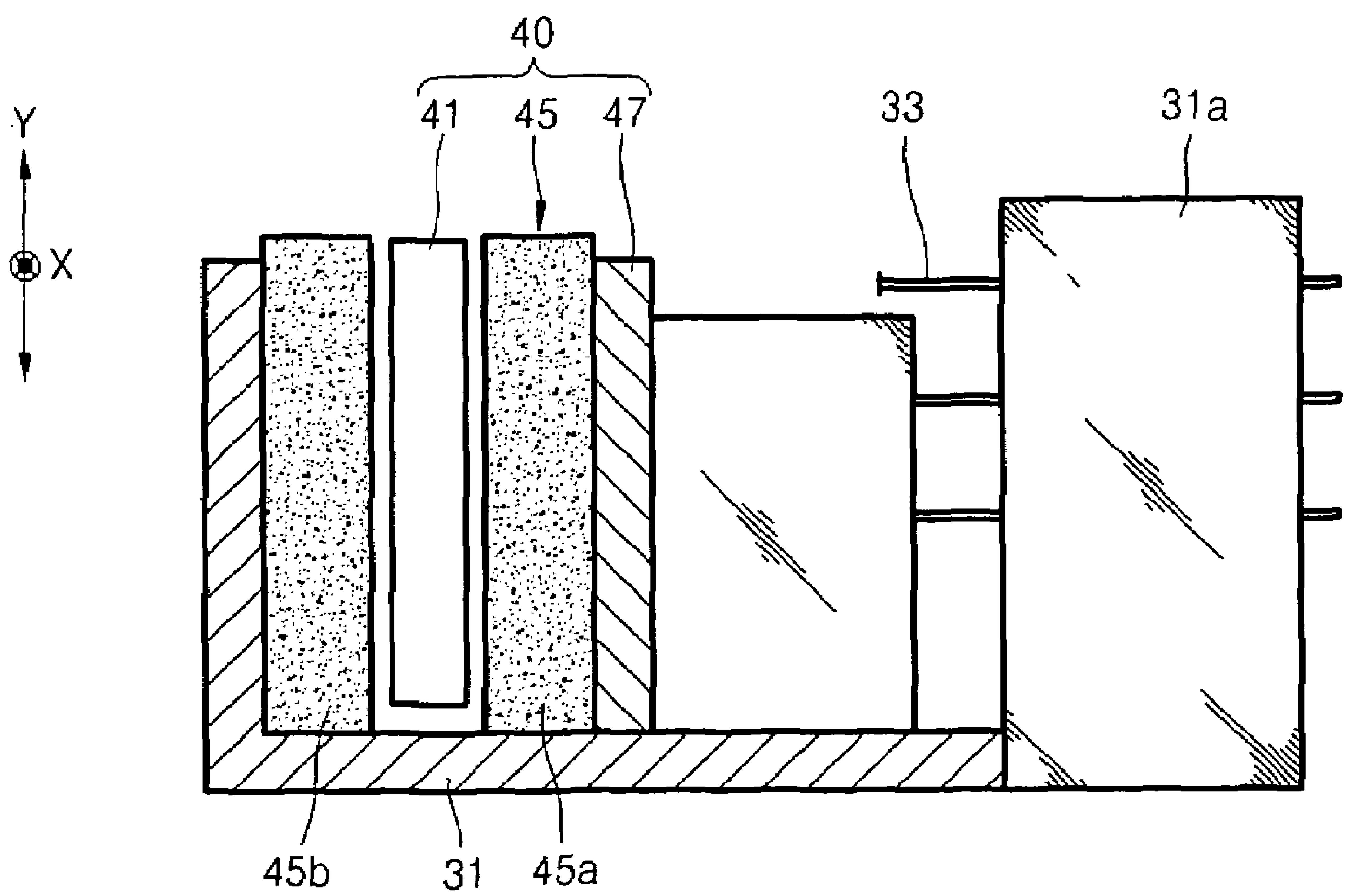


FIG. 7

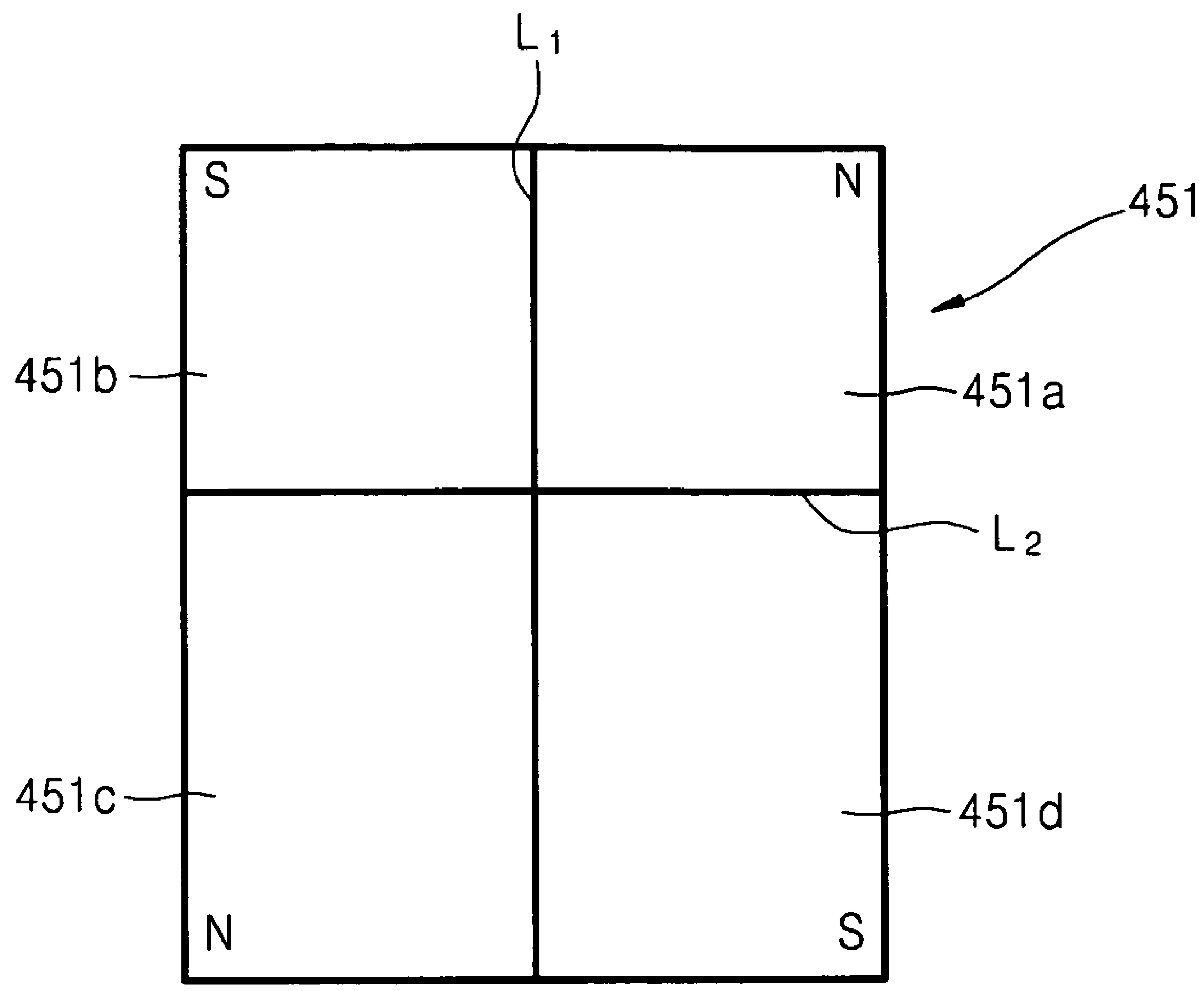

L1
S
N
451
451b
451a
L2
451c
451d
N
S

FIG. 8

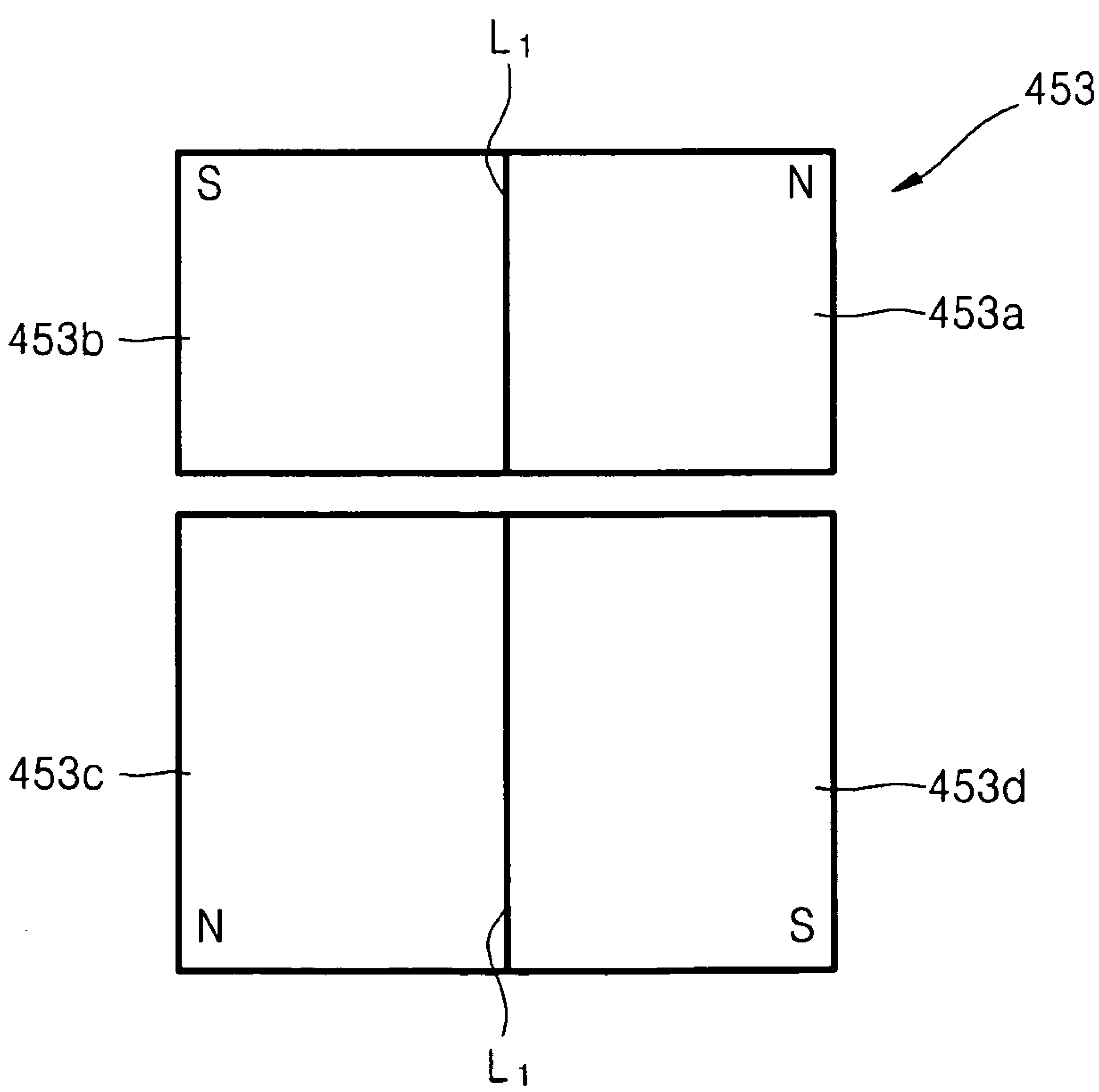

L1
453
S
N
453b
453a
453c
453d
N
S
L1

FIG. 9

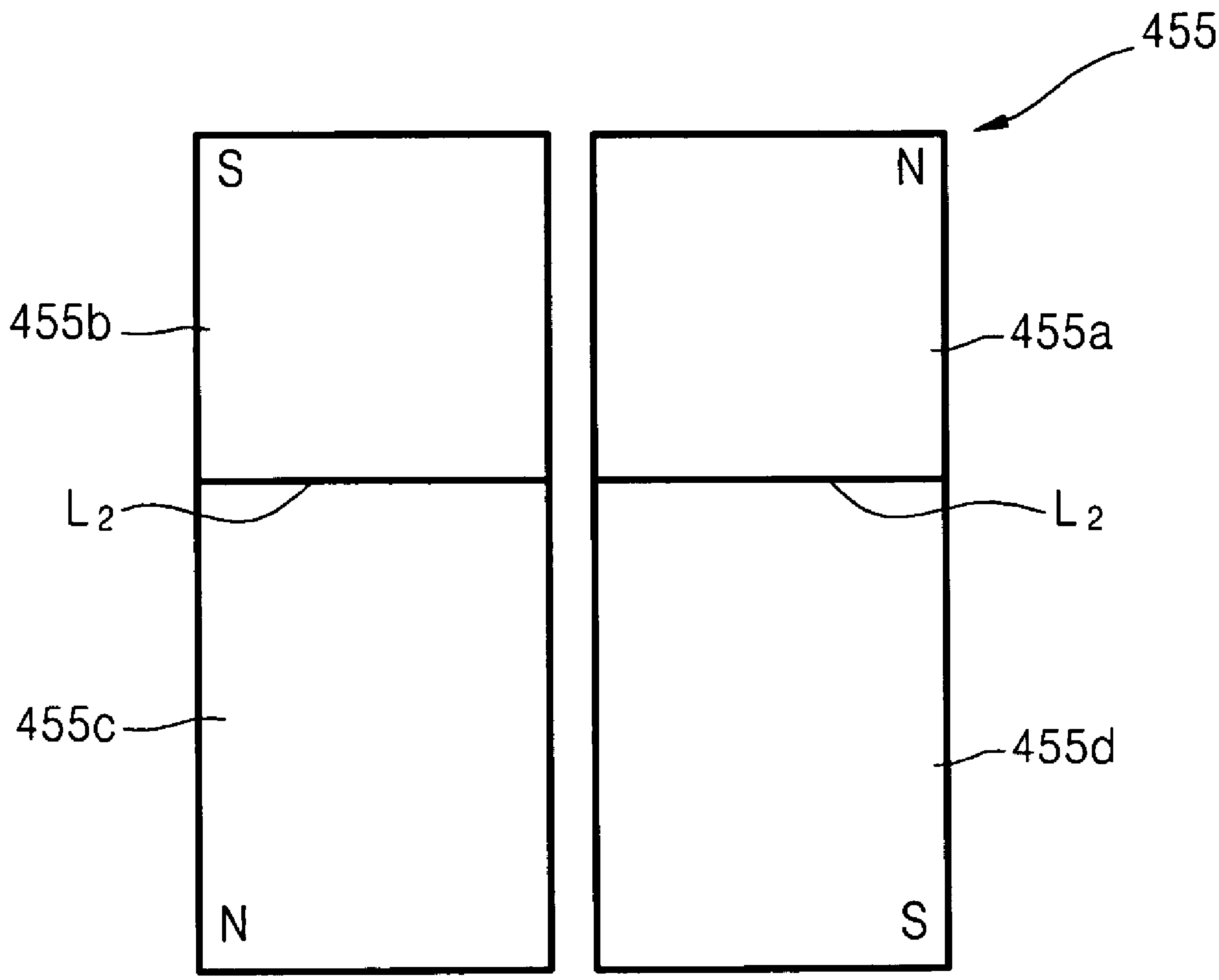
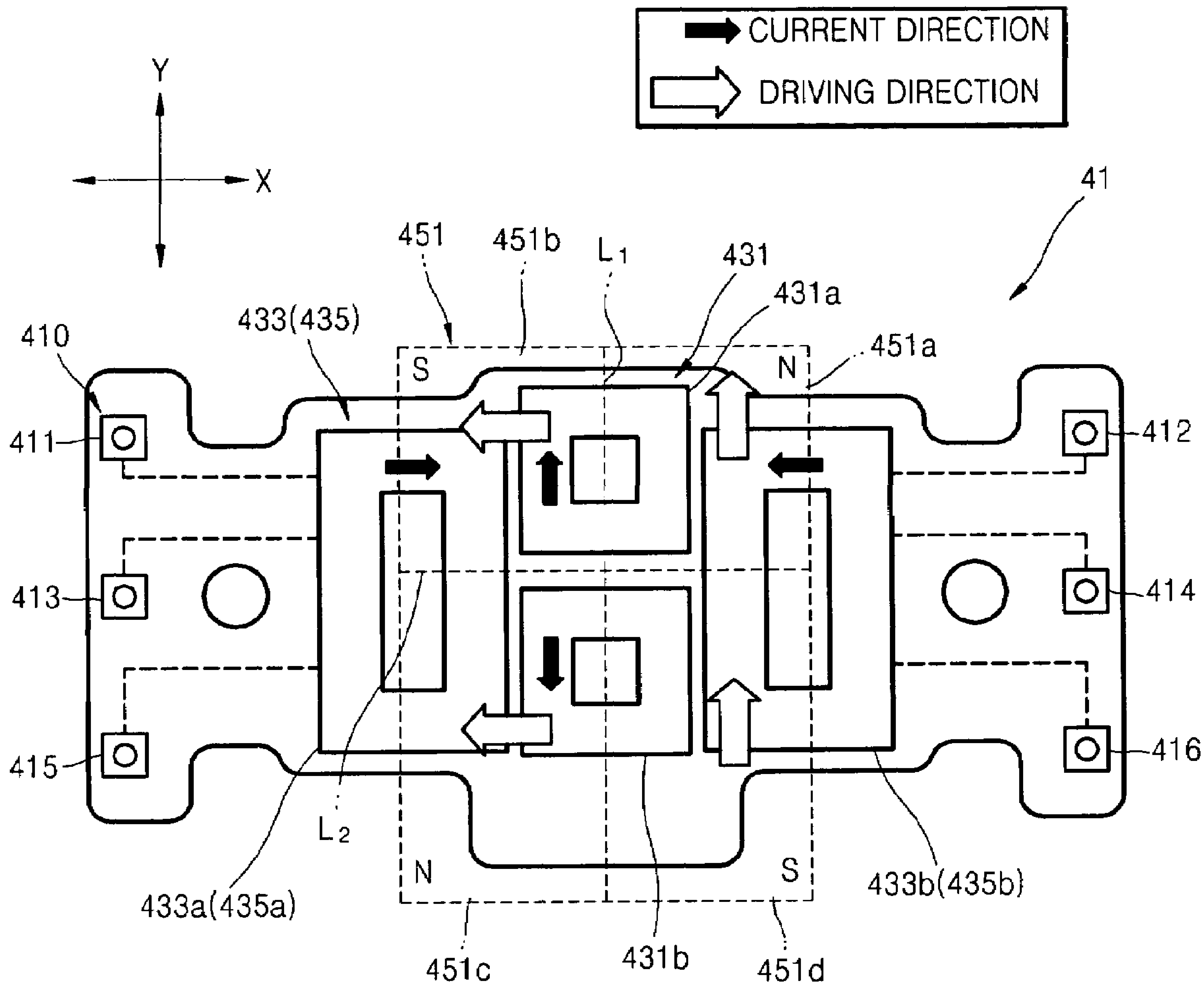


FIG. 10



CURRENT DIRECTION
DRIVING DIRECTION
Y
X
41
451
451b
L1
431
431a
451a
410
433(435)
S
N
411
412
413
414
415
416
L2
N
S
433a(435a)
433b(435b)
451c
431b
451d

FIG. 11A

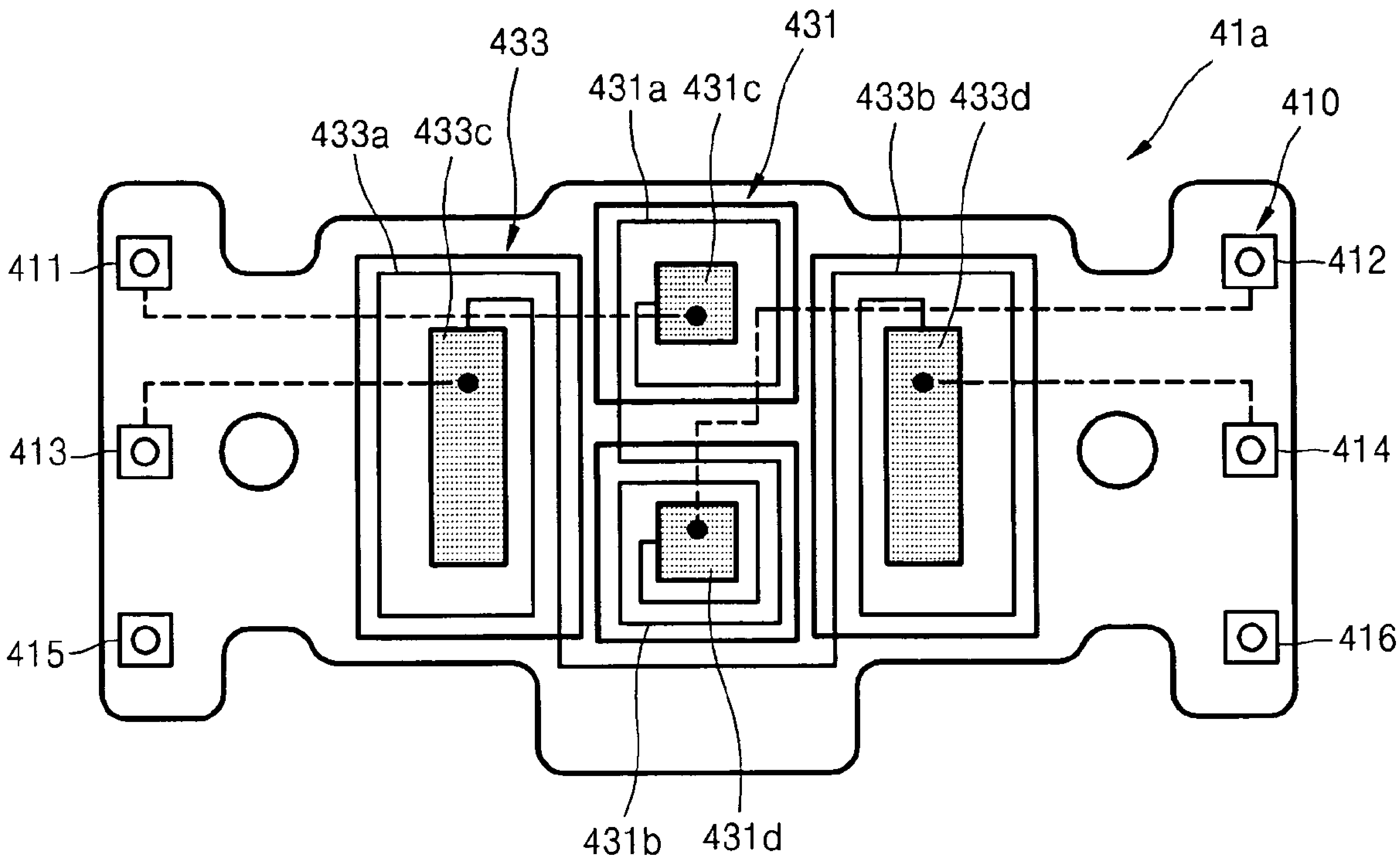
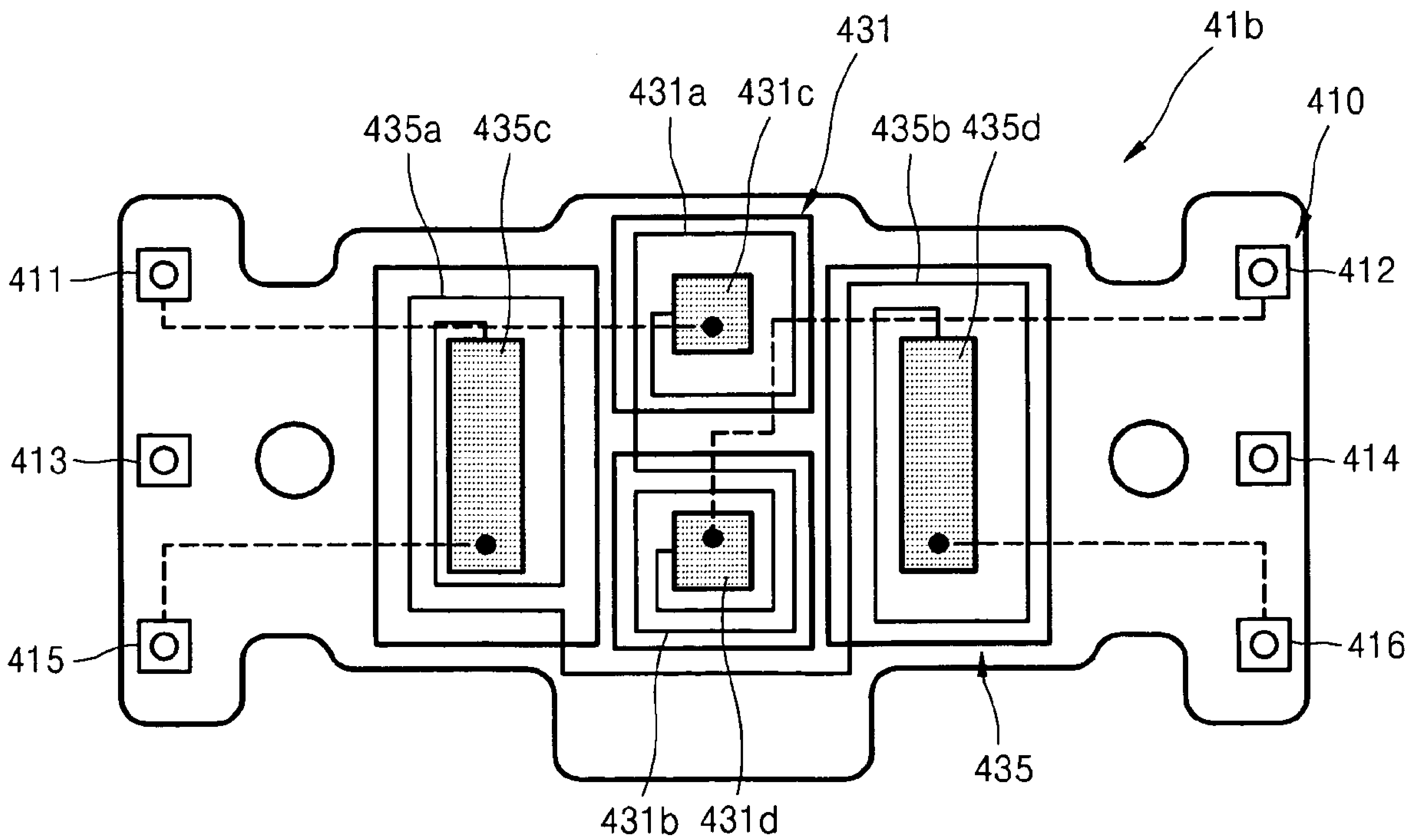


FIG. 11B



OPTICAL PICKUP ACTUATOR FOR DRIVING AN OBJECTIVE LENS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of Korean Patent Application No. 10-2006-0018519, filed on Feb. 25, 2006, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical pickup actuator used for an optical recording and reproducing apparatus. More particularly, to a slim-type 3-axis driving optical pickup actuator using a fine pattern coil (FPC).

2. Description of the Related Art

A conventional optical pickup is used for an optical recording and reproducing apparatus and performs recording and/or reproduction of information in a non-contact manner with respect to an optical disk (i.e., an information storage medium). The optical pickup requires an optical pickup actuator capable of driving an objective lens in a track direction, a focus direction, and/or a tilt direction to form an optical spot at a correct position on the optical disk.

As high density optical disks become popular, the optical pickup and optical pickup actuator tend to be compact and light. In particular, for the optical pickup actuator to perform the recording/reproducing of information with respect to the high density optical disk, 3-axis driving, i.e. driving in the track direction, the focus direction, and the tilt direction, is necessary. Also, to make the optical pickup compact and light, the size of the optical pickup actuator needs to be small. Accordingly, an optical pickup actuator using a fine pattern coil capable of driving in three axes is needed.

FIGS. **1**-**3** illustrates a conventional optical pickup actuator using a fine pattern coil. As shown in FIG. **1**, the conventional optical pickup actuator includes a base **1**, a blade **5** supported by a suspension **3** and installed on the base **1** to be capable of moving, a magnetic circuit **10** dividedly installed on the blade **5** and the base **1**, and a stopper **9** restricting a driving height during the driving of the blade **5**.

An objective lens **7** is installed on the blade **5**. As the blade **5** is driven by a driving force through the magnetic circuit **10**, the objective lens **7** is driven in the track direction, the focus direction, and the tilt direction.

Thus, the magnetic circuit **10** includes a fine pattern coil **11** fixed to the blade **5**, a pair of magnets **15** arranged to face each other with respect to the fine pattern coil **11** interposed therebetween, and a yoke **17** fixing the magnet **15** to the base **1** and forming a magnetic path. The magnets **15** are 2-pole magnetized permanent magnets. In FIGS. **1**-**3**, the magnets **15** are illustrated as being surface polarized to the left and right.

The fine pattern coil **11** is divided into focus coils **12***a* and **12***b* and a track coil **13** according to the direction to drive the blade **5**. The focus coil includes first and second focus coils **12***a* and **12***b* which are separated from a polarization line **15***a* of the magnet **15** that is polarized to the left and right. Thus, when current is applied, the focus coils **12***a* and **12***b* make the fine pattern coil **11** and the blade **5** driven in a Y-axis direction. To this end, the first and second focus coils **12***a* and **12***b* are arranged such that a part of the focus coils **12***a* and **12***b* parallel to the X-axis direction faces the magnet **15**, and contribute to the driving in the focus direction. Thus, the other part (the lower portion in the drawing) of the focus coils **12***a* and **12***b* does not face the magnet **15** to prevent the offset of a driving force.

The track coil **13** is arranged in front of the polarization line **15***a* of the magnet **15** and drives the blade **5** in the X-axis direction when current is applied to the track coil **13**. The track coil **13** is arranged such that a part of the track coil **13** parallel to a Y-axis direction faces the magnet **15**, and contribute to the driving in the tracking direction.

In the conventional optical pickup actuator using a fine pattern coil configured as above, as shown in FIG. **3**, when magnetic poles of the magnet **15** are arranged, an N pole and an S pole are respectively arranged in the left and right sides with respect to the polarization line **15***a*. When current is applied to the focus coils **12***a* and **12***b* in a direction indicated by arrows (→), the blade **5** is driven in a direction indicated by arrow (→).

In the above conventional optical pickup actuator, tilt driving is performed, not by including an additional tilt coil, but instead by using the first and second focus coils **12***a* and **12***b*. That is, input/output ports of current with respect to each of the first and second focus coils **12***a* and **12***b* are independently configured. Current of a different direction or intensity is applied to the input/output ports. Thus, the focus driving and tilt driving are performed using a difference in the driving forces.

Thus, since the conventional optical pickup actuator includes a structure to perform both focus driving and tilt driving using the first and second focus coils **12***a* and **12***b*, a drive circuit is complicated and a correction error may be generated when the driving to correct a focus error and the driving to correct a tilt error are simultaneously performed. Also, in the arrangement of the first and second focus coils **12***a* and **12***b* and the magnet **15**, since only the upper portions of the first and second focus coils **12***a* and **12***b* are used, a magnetic force is weak.

SUMMARY OF THE INVENTION

Accordingly, it is an aspect of the present invention to provide an optical actuator using a fine pattern coil which increases a magnetic driving force by improving the arrangement structure between the focus coil and the magnet and reduce a drive error by configuring an independent tilt coil.

Additional aspects and/or advantages of the invention will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

The foregoing and/or other aspects of the present invention are achieved by providing an optical pickup actuator including a base, a blade having an objective lens mounted thereon, a plurality of suspensions supporting the blade to be movable with respect to the base and providing an electroconductive path, and a magnetic circuit driving the blade according to a driving signal applied through the respective suspensions, wherein the magnetic circuit includes a magnet fixed to the base, and a fine pattern coil installed on the blade at a position facing the magnet, and having a track pattern coil, a focus pattern coil, and a tilt pattern coil, independently driven by current applied through the suspensions and providing driving forces in a track direction, a focus direction, and a tilt direction of the blade.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects and advantages of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a plan view of a conventional optical pickup actuator;

FIG. **2** is a cross-sectional view of a part of the conventional optical pickup actuator of FIG. **1**;

FIG. **3** is a view of the arrangement of the fine pattern coil and the magnet of the conventional optical pickup actuator shown in FIG. **1** and a driving direction according to the direction of current;

FIG. **4** is a perspective view of an optical pickup actuator according to an embodiment of the present invention;

FIG. **5** is a plan view of the optical pickup actuator of FIG. **4**;

FIG. **6** is a cross-sectional view of a part of the optical pickup actuator of FIG. **4**;

FIGS. **7-9** are views illustrating the arrangements of magnetic poles of magnets according to embodiments of the present invention;

FIG. **10** is a view illustrating the arrangement of the fine pattern coil and the magnet of FIG. **4** and a driving direction according to the direction of current; and

FIGS. **11**A and **11**B are view illustrating the arrangements of coils and electrodes on different layers of the fine pattern coil.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below to explain the present invention by referring to the figures.

FIGS. **4** and **5** are a perspective view and a plan view of an optical pickup actuator according to an embodiment of the present invention. FIG. **6** is a cross-sectional view of a major part of the optical pickup actuator of FIG. **4**. As shown in FIGS. **4-6**, an optical pickup actuator according to an embodiment of the present invention comprises a base **31**, a blade **35** on which an objective lens **37** is mounted, a plurality of suspensions **33** supporting the blade **35** to be movable with respect to the base **31**, and a magnetic circuit **40** driving the blade **35**. The suspensions **33** provide electroconductive paths through which current is applied to a fine pattern coil **41** which constitutes the magnetic circuit **40**. Thus, in this embodiment of the present invention, the suspensions **33** are six suspension wires, for example, as shown in FIG. **4**. However, the present invention is not limited hereto, and may vary as necessary.

The base **31** is installed to be movable in a radial direction of an optical recording medium with respect to an optical information recording/reproducing apparatus. The base **31** comprises a holder **31***a* to support an end of the suspensions **33**. As the blade **35** is operated by a driving force through the magnetic circuit **40**, the objective lens **37** is independently driven in a track direction, a focus direction, and a tilt direction (i.e., 3-axis driving).

Thus, the magnetic circuit **40** comprises a magnet **45** fixed to the base **31** and a fine pattern coil **41** installed at a position facing the magnet **45** of the blade **35**. According to an embodiment of the present invention, the fine pattern coil **41** is directly formed on the blade **35** by insert molding or assembly, for example. As the fine pattern coil **41** is formed as described later, an electrode **410** of FIG. **10** and the suspensions **33** can be directly and electrically connected.

The magnet **45** comprises first and second magnets **45***a* and **45***b* arranged to face each other with respect to the fine pattern coil **41** interposed therebetween. In this case, since a magnetic driving force between the fine pattern coil **41** and the magnet **45** is increased, more accurate driving control is available. Further, a yoke **47** which fixes the magnet **45** to the base **31** and forms a magnetic path is provided. The arrangement of magnetic poles of the magnet **45** according to an embodiment of the present invention will be described with reference to FIGS. **7-9**.

FIG. **7** is a view illustrating the arrangement of magnetic poles of a magnet according to an embodiment of the present invention. As shown in FIG. **7**, a magnet **451**, according to an embodiment of the present invention, is a magnet which is 4-pole magnetized and surface divided for example. That is, the magnet **451** has a 2×2 format and is sectioned in a cross type along a first polarization line L_1 parallel to the focus driving direction (Y direction) of the blade **35** and a second polarization line L_2 parallel to a track driving direction (X direction) of the blade **35**. The magnet **451** comprises first through fourth magnet portions **451***a*, **451***b*, **451***c*, and **451***d* respectively arranged in the first through fourth quadrants. The neighboring magnet portions are polarized to have the opposite poles. For example, in the first and third magnet portions **451***a* and **451***c*, N poles face the fine pattern coil **41** while, in the second and fourth magnet portions **451***b* and **451***d*, S poles face the fine pattern coil **41**. The present invention is not limited hereto, and may vary as necessary.

The above arrangement of the magnet **451** is an example of one of two magnets arranged to face each other. Accordingly, the other magnet has the same sectional structure but the opposite magnetic pole arrangement. For example, when the magnetic pole arrangement of the magnet **451** is that of a portion of the first magnet **45***a* of FIG. **6** facing the fine pattern coil **41**, in the magnetic pole arrangement of a portion of the second magnet **45***b* of FIG. **6** facing the fine pattern coil **41**, the magnet portions facing the first and third magnet portions **451***a* and **451***c* are S poles while the magnet portions facing the second and fourth magnet portions **451***b* and **451***d* are N poles.

When the first through fourth magnet portions **451***a*, **451***b*, **451***c*, and **451***d* are arranged as above, since an interval space between the respective magnet portions is not formed, the base **31** is easily assembled.

FIG. **8** is a view illustrating the arrangement of magnetic poles of a magnet according to another embodiment of the present invention. As shown in FIG. **8**, a magnet **453** according to an embodiment of the present invention is two magnets, each of which is 2-pole magnetized and surface divided, for example. The magnet **453** comprises first through fourth magnet portions **453***a*, **453***b*, **453***c*, and **453***d*. The first and second magnet portions **453***a* and **453***b* are arranged close to each other and the magnetic poles thereof are polarized to be opposite to each other with respect to the first polarization line L_1 that is parallel to the focus driving direction (Y direction) of the blade **35**. The third and fourth magnet portions **453***c* and **453***d* are arranged close to each other and the magnetic poles thereof are polarized to be opposite to each other with respect to the first polarization line L_1. The third and fourth magnet portions **453***c* and **453***d* are respectively separated a predetermined distance from the second and first magnet portions **453***b* and **453***a* in the focus direction (Y) of the blade **35**. Also, the first and fourth magnet portions **453***a* and **453***d* have the opposite magnetic poles while the second and third magnetic portions **453***b* and **453***c* have the opposite magnetic poles. For example, the first and third magnetic portions **453***a* and **453***c* have N poles to face the fine pattern coil **41** while the second and fourth magnetic portions **453***b* and **453***d* have S poles to face the fine pattern coil **41**.

The above arrangement of the magnet **453** is an example of one of two magnets arranged to face each other. Accordingly, the other magnet has the same sectional structure but the opposite magnetic pole arrangement. In this embodiment of the present invention, since the gap between the magnetic portions in the focus direction is larger than that FIG. **7**, the driving force in the focus direction can be improved.

FIG. **9** is a view illustrating the arrangement of the magnetic poles of a magnet according to yet another embodiment of the present invention. As shown in FIG. **9**, a magnet **455** according to yet another embodiment of the present invention comprises two magnets, each of which is 2-pole magnetized and surface divided, for example. The magnet **455** comprises first through fourth magnet portions **455***a*, **455***b*, **455***c*, and **455***d*. The first and fourth magnet portions **455***a* and **455***d* are arranged close to each other and the magnetic poles thereof are polarized to be opposite to each other with respect to the second polarization line L_2 that is parallel to the track driving direction (X direction) of the blade **35**. The second and third magnet portions **455***b* and **455***c* are arranged close to each other and the magnetic poles thereof are polarized to be opposite to each other with respect to the second polarization line L_2. The second and third magnet portions **455***b* and **455***c* are respectively separated a predetermined distance from the first and fourth magnet portions **455***a* and **455***d* in the track direction (X) of the blade **35**. Also, the first and second magnet portions **455***a* and **455***b* have the opposite magnetic poles while the third and fourth magnetic portions **455***c* and **455***d* have the opposite magnetic poles. For example, the first and third magnetic portions **455***a* and **455***c* have N poles to face the fine pattern coil **41** while the second and fourth magnetic portions **455***b* and **455***d* have S poles to face the fine pattern coil **41**.

The above arrangement of the magnet **455** is an example of one of two magnets arranged to face each other. Accordingly, the other magnet has the same sectional structure but the opposite magnetic pole arrangement. In this case, since the gap between the magnet portions in the track direction is larger than that of FIG. **7**, the driving force in the focus direction can be improved.

FIG. **10** is a view illustrating the arrangement of the fine pattern coil **41** and the magnet **451** of FIG. **7** and a driving direction according to the direction of current. FIGS. **11**A and **11**B are view illustrating the arrangements of coils and electrodes on different layers of the fine pattern coil. As shown in FIGS. **10**, **11***a* and **11**B, the structure of the fine pattern coil **41** and the interaction between the magnets and the fine pattern coil **41** will be described in detail.

As shown in FIGS. **10**, **11**A, and **11**B, the fine pattern coil **41** is independently driven by current applied through the suspensions **33** and comprises a track pattern coil **431**, a focus pattern coil **433**, and a tilt pattern coil **435** respectively providing driving force in the track direction (X axis), the focus direction (Y axis), and the tilt direction of the blade **35**.

The fine pattern coil **41** comprises a stacked structure of at least two pattern coil layers that are electrically insulated. A plurality of electrodes **410** electrically connected with the respective suspensions **33** of FIG. **4** are formed at positions corresponding to the respective fine pattern coil layers. As shown in FIG. **10**, the electrode **410** comprises first through sixth electrodes **411**-**416** which are electrically connected with both of the respective suspensions **33** and the fine pattern coil **41**. That is, the first and second electrodes **411** and **412** are electrically connected with the track pattern coil **431**, the third and fourth electrodes **413** and **414** are electrically connected with the focus pattern coil **433**, and the fifth and sixth electrodes **415** and **416** are electrically connected with the tilt pattern coil **435**. Thus, by applying current independently to each of the first through sixth electrodes **411**-**416**, the track pattern coil **431**, the focus pattern coil **433**, and the tilt pattern coil **435** can be selectively and independently driven.

FIGS. **11**A and **11**B illustrate an example in which the fine pattern coil **41** includes first and second pattern coil layers **41***a* and **41***b*. As shown in FIG. **11**A, the first through sixth electrodes **411**-**416** connected with the suspensions **33** of FIG. **4**, the track pattern coil **431** electrically connected with the first and second electrodes **411** and **412**, and the focus pattern coil **433** electrically connected with the third and fourth electrodes **413** and **414** are formed on the first pattern coil layer **41***a*. As shown in FIG. **11**B, the first through sixth electrodes **411**-**416** connected with the suspensions **33** of FIG. **4**, the track pattern coil **431** electrically connected with the first and second electrodes **411** and **412**, and the tilt pattern coil **435** electrically connected with the fifth and sixth electrodes **415** and **416** are formed on the second pattern coil layer **41***b*.

Since the first through sixth electrodes **411**-**416** and the track pattern coil **431** formed on the first and second pattern coil layers **41***a* and **41***b* have substantially the same structure and perform the same function, thus, the same reference numerals are used. That is, since the first through sixth electrodes **411**-**416** of the first pattern coil layer **41***a* are electrically connected with the first through sixth electrodes **411**-**416** of the second pattern coil layer **41***b*, respectively, when current is applied through the suspensions **33** of FIG. **4**, a driving force is generated by an interactive electromagnetic force between the track, focus, and tilt pattern coils **431**, **433**, and **435** and the magnet **45**.

Also, the track pattern coils **431** formed on the first and second pattern coil layers **41***a* and **41***b* are arranged to face each other when the fine pattern coil **41** is formed by depositing the first and second pattern coil layers **41***a* and **41***b*, and the portions facing each other are wound in a same rotation direction.

The track pattern coil **431** comprises first and second track pattern coil portions **431***a* and **431***b*. The first track pattern coil portion **431***a* is electrically connected with the first electrode **411** through a first port **431***c*. When the magnet **451** configured as shown in FIG. **7** is provided, the first track pattern coil portion **431***a* is arranged to face each of the first and second magnet portions **451***a* and **451***b*. That is, each of two parts of the first track pattern coil portion **431***a* parallel to the Y axis is arranged at a different position with respect to the first polarization line L_1.

The second track pattern coil portion **431***b* is electrically connected with the second electrode **412** through a second port **431***d*. Also, the first port **431***c* and the second port **431***d* are electrically connected with each other. When the magnet **451** configured as shown in FIG. **7** is provided, the second track pattern coil portion **431***b* is arranged to face each of the third and fourth magnet portions **451***c* and **451***d*. That is, each of two parts of the second track pattern coil portion **431***b* parallel to the Y axis is arranged at a different position with respect to the first polarization line L_1.

Also, the second track pattern coil portion **431***b* is wound in a direction opposite to a direction in which a coil of the first track pattern coil portion **431***a* is wound. Thus, as shown in FIG. **10**, when current is applied clockwise to the first track pattern coil portion **431***a*, the current is applied counterclockwise to the second track pattern coil portion **431***b*. The magnetic poles of the magnet **451** respectively facing the first and second track pattern coil portions **431***a* and **431***b* are provided opposite to each other. Thus, the current is applied to the first track pattern coil portion **431***a* in a direction indicated by an arrow "↑" and to the second track pattern coil portion **431***b* in a direction indicated by an arrow "↓", the blade **35** of FIG. **4** is driven in a track direction indicated by an arrow "←", that is, in a direction −X axis. Reversely, when the current is applied in a direction opposite to the direction shown in FIG. **10**, the blade **35** is driven in the +X axis direction according to the above-described principle.

Thus, the driving of the blade **35** and the objective lens **37** mounted thereon in the track direction can be performed by the direction of the current applied to the first and second track pattern coil portions **431***a* and **431***b* and an interactive electromagnetic force between the first through fourth magnet portions **451***a*, **451***b*, **451***c*, and **451***d*.

The focus pattern coil **433** and the tilt pattern coil **435** formed on each of the first and second pattern coil layers **41***a* and **41***b* are arranged to face to each other by depositing the first and second pattern coil layers **41***a* and **41***b* when the fine pattern coil **41** is formed. At least part of the portions facing each other is wound in a different rotation direction.

As shown in FIG. **11**A, the focus pattern coil **433** comprises first and second focus pattern coil portions **433***a* and **433***b* which are arranged at both side positions with respect to the track pattern coil **431** interposed therebetween. The first focus pattern coil portion **433***a* is electrically connected with the third electrode **413** through a third port **433***c*. As shown in FIG. **10**, when the magnet **451** configured as shown in FIG. **7** is provided, at least part of the first focus pattern coil portion **433***a* is arranged to face each of the second and third magnet portions **451***b* and **451***c*. That is, each of two portions of the first focus pattern coil portion **433***a* parallel to the X axis is arranged at a different position with respect to the second polarization line L_2.

The second focus pattern coil portion **433***b* is electrically connected with the fourth electrode **414** through a fourth port **433***d*. The third port **433***c* and the fourth port **433***d* are electrically connected with each other. When the magnet **451** configured as shown in FIG. **7** is provided, at least part of the second focus pattern coil portion **433***b* is arranged to face each of the first and fourth magnet portions **451***a* and **451***d*. That is, each of the two portions of the second focus pattern coil portion **433***b* parallel to the X axis is arranged at a different position with respect to the second polarization line L_2.

Also, the second focus pattern coil portion **433***b* is wound in a direction opposite to a direction in which a coil of the first focus pattern coil portion **433***a* is wound. Thus, as shown in FIG. **10**, when current is applied clockwise to the first focus pattern coil portion **433***a*, the current is applied counterclockwise to the second focus pattern coil portion **433***b*. The magnetic poles of the magnet **451** respectively facing the first and second focus pattern coil portions **433***a* and **433***b* are provided opposite to each other. Thus, the current is applied to the first focus pattern coil portion **433***a* in a direction indicated by an arrow "→" and to the second focus pattern coil portion **433***b* in a direction indicated by an arrow "←", the blade **35** of FIG. **4** is driven in a focus direction indicated by an arrow "↑", that is, in a direction +Y axis. Reversely, when the current is applied in the opposite direction, the blade **35** is driven in the −Y axis direction according to the same principle.

Thus, the driving of the blade **35** and the objective lens **37** mounted thereon in the focus direction can be performed by the direction of the current applied to the first and second focus pattern coil portions **433***a* and **433***b* and the interactive electromagnetic force between the first through fourth magnet portions **451***a*, **451***b*, **451***c*, and **451***d*.

As shown in FIG. **11**B, the tilt pattern coil **435** comprises first and second tilt pattern coil portions **435***a* and **435***b* which are arranged at both side positions with respect to the track pattern coil **431** interposed therebetween. The first tilt pattern coil portion **435***a* is electrically connected with the fifth electrode **415** through a fifth port **435***c*. When the magnet **451** configured as shown in FIG. **7** is provided, at least part of the first tilt pattern coil portion **435***a* is arranged to face each of the second and third magnet portions **451***b* and **451***c*. That is, each of two portions of the first tilt pattern coil portion **435***a* parallel to the X axis is arranged at a different position with respect to the second polarization line L_2.

The second tilt pattern coil portion **435***b* is electrically connected with the sixth electrode **416** through a sixth port **435***d*. The fifth port **435***c* and the sixth port **435***d* are electrically connected with each other. When the magnet **451** configured as shown in FIG. **7** is provided, at least part of the second tilt pattern coil portion **435***b* is arranged to face each of the first and fourth magnet portions **451***a* and **451***d*. That is, each of the two portions of the second tilt pattern coil portion **435***b* parallel to the X axis is arranged at a different position with respect to the second polarization line L_2.

Also, the second tilt pattern coil portion **435***b* is wound in a direction in which a coil of the first tilt pattern coil portion **435***a* is wound. Thus, as shown in FIG. **10**, when current is applied clockwise to the first tilt pattern coil portion **435***a*, the current is also applied clockwise to the second tilt pattern coil portion **435***b* unlike the focus pattern coil **433**. The magnetic poles of the magnet **451** respectively facing the first and second tilt pattern coil portions **435***a* and **435***b* are provided opposite to each other. Thus, when the current is applied to the first tilt pattern coil portion **435***a* in a direction indicated by an arrow "→", the blade **35** of FIG. **4** is driven in a direction indicated by an arrow "↑", that is, in a direction +Y axis, in a portion corresponding thereto. Meanwhile, the current is applied to the second tilt pattern coil portion **435***b* in the same direction indicated by the arrow "→". Thus, since in this case the poles of the magnet **45** are arranged to be opposite to each other, the blade **35** of FIG. **4** is driven in a direction indicated by an arrow "↓" (not shown), that is, in the −Y axis direction, in a portion corresponding thereto. Accordingly, the blade **35** is tilt driven in the clockwise direction. Meanwhile, when the current is applied in the opposite direction, the blade **35** is tilt driven in the counterclockwise direction according to the same principle.

Thus, the driving of the blade **35** and the objective lens **37** mounted thereon in the tilt direction can be performed by the direction of the current applied to the first and second tilt pattern coil portions **435***a* and **435***b* and the interactive electromagnetic force between the first through fourth magnet portions **451***a*, **451***b*, **451***c*, and **451***d*.

The fine pattern coil **41** according to the present invention is not limited to the above-described 2-layer deposition structure having the first and second pattern coil layers **41***a* and **41***b*, and can have a variety of layer structures, for example, four layers or six layers considering a desired intensity of the magnetic driving force.

As described above, since the optical pickup actuator according to an embodiment of the present invention uses the fine pattern coil, a slim-type optical pickup actuator having a height which is greatly reduced can be provided. Also, since the fine pattern coil is formed in the blade in insert molding or directly assembly, and the suspensions and the fine pattern coil are directly connected without using an additional part such as a print circuit board, mass production and assembly accuracy can be secured.

Furthermore, the structure and arrangement of the magnet are improved so that both the upper and lower portions of the focus pattern coil are involved in the focus driving. Thus, the magnetic driving force in the focus direction can be increased. In addition, since the track pattern coil is formed in the upper and lower portions of the magnet with respect to the second polarization line, an effective coil area contributing to the magnetic driving force in the track driving direction can be extended so that the deterioration of sensitivity performance is prevented and negative oscillation due to a leakage magnetic flux is greatly reduced. In forming the fine pattern coil in a multilayer structure, since an independent fine pattern coil is provided, the tilt driving can be performed, without being affected by the focus driving so that driving error can be reduced.

Although a few embodiments of the present invention have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. An optical pickup actuator comprising a base, a blade having an objective lens mounted thereon, a plurality of suspensions supporting the blade to be movable with respect to the base and providing an electroconductive path, and a magnetic circuit driving the blade according to a driving signal applied through the respective suspensions,

wherein the magnetic circuit comprises:

a magnet fixed with the base; and

a fine pattern coil installed on the blade at a position facing the magnet, and comprising a track pattern coil, a focus pattern coil, and a tilt pattern coil independently driven by current applied through the suspensions and providing driving forces in a track direction, a focus direction, and a tilt direction of the blade;

wherein the fine pattern coil comprises first and second fine pattern coil layers which are electrically insulated from each other; and

wherein the first fine pattern coil layer comprises the track pattern coil and the focus pattern coil and the second fine pattern coil layer comprises the track pattern coil and the tilt pattern coil.

2. The optical pickup actuator of claim **1**, wherein the magnet is sectioned by a first polarization line parallel to a focus driving direction of the blade and a second polarization line parallel to a track driving direction of the blade, and being of a 2–2 format which comprises first through fourth magnet portions arranged in first through fourth quadrants, and magnetic poles of neighboring magnet portions are polarized to have the opposite poles.

3. The optical pickup actuator of claim **1**, wherein the magnet comprises:

first and second magnet portions which are arranged close to each other and comprise magnetic poles polarized to be opposite to each other with respect to a first polarization line parallel to a focus driving direction of the blade; and

third and fourth magnet portions which are arranged close to each other and comprise magnetic poles polarized to be opposite to each other with respect to the first polarization line, and

the third and fourth magnet portions are separated a predetermined distance in the focus driving direction of the blade from the second and first magnet portions, respectively, and comprise magnetic poles that are opposite to those of the second and first magnets.

4. The optical pickup actuator of claim **1**, wherein the magnet comprises:

first and fourth magnet portions which are arranged close to each other and comprise magnetic poles polarized to be opposite to each other with respect to a second polarization line parallel to a track driving direction of the blade; and

second and third magnet portions which are arranged close to each other and comprise magnetic poles polarized to be opposite to each other with respect to the second polarization line, and

the second and third magnet portions are separated a predetermined distance in the track driving direction of the blade from the first and fourth magnet portions, respectively, and have magnetic poles that are opposite to those of the first and fourth magnets.

5. The optical pickup actuator of claim **1**, further comprising a yoke which fixes the magnet to the base and forms a magnetic path.

6. The optical pickup actuator of claim **1**, wherein the magnet comprises first and second magnets arranged to face each other with respect to the fine pattern coil interposed therebetween.

7. The optical pickup actuator of claim **2**, wherein the fine pattern coil further comprises:

a plurality of electrodes electrically connected with the respective suspensions formed on each of the first and second fine pattern coil layers at positions corresponding thereto.

8. The optical pickup actuator of claim **7**, wherein

the, track pattern coil is electrically connected with first and second electrodes of the plurality of electrodes, the focus pattern coil is electrically connected with third and fourth electrodes of the plurality of electrodes; and the tilt pattern coil is electrically connected with fifth and sixth electrodes of the plurality of electrodes.

9. The optical pickup actuator of claim **8**, wherein the track pattern coil comprises first and second track pattern coil portions and wherein the first and second track pattern coil portions are formed on the first and second fine pattern coil layers and are arranged to face each other when the fine pattern coil is formed by depositing the first and second fine pattern coil layers, and the track pattern coil portions facing to each other are wound in a same rotation direction.

10. The optical pickup actuator of claim **9**, wherein

the first track pattern coil portion is electrically connected with the first electrode and arranged to face the first and second magnet portions; and

the second track pattern coil portion is electrically connected with the first track pattern coil portion and the second electrode and arranged to face the third and fourth magnet portions,

wherein driving of the blade in the track direction is performed by a direction of current applied to the first and second track pattern coil portions and an interactive electromagnetic force between the first through fourth magnet portions.

11. The optical pickup actuator of claim **8**, wherein the focus pattern coil and the tilt pattern coil formed on each of the first and second pattern coil layers are arranged to face each other when the fine pattern coil is formed by depositing the first and second pattern coil layers, and portions of the focus pattern coil and the tilt pattern coil facing to each other are wound in a same rotation direction.

12. The optical pickup actuator of claim **11**, wherein the focus pattern coil comprises: first and second focus pattern coil portions arranged at both side positions with respect to the track pattern coil interposed therebetween, the first focus pattern coil portion is electrically connected with the third electrode and arranged to face the second and third magnet portions to interact each other, and the second focus pattern coil portion is electrically connected with the first focus pattern coil portion and the fourth electrode and arranged to face the second and third magnet portions to interact each other.

13. The optical pickup actuator of claim **12**, wherein the first focus pattern coil portion and the second focus pattern coil portion are wound in opposite rotation directions.

14. The optical pickup actuator of claim **11**, wherein the tilt pattern coil comprises first and second tilt pattern coil portions arranged at both side positions with respect to the track pattern coil interposed therebetween, the first tilt pattern coil portion is electrically connected with the fifth electrode and arranged to face the second and third magnet portions to interact each other, and the second tilt pattern coil portion is electrically connected to the first tilt pattern coil portion and the sixth electrode and arranged to face the first and fourth magnet portions to interact each other.

15. The optical pickup actuator of claim **14**, wherein the tilt focus pattern coil portion and the second tilt pattern coil portion are wound in a same rotation direction.

16. An optical pickup actuator comprising:

a base;

a blade having an objective lens mounted thereon;

a plurality of suspensions supporting the blade to be movable with respect to the base and providing an electro-conductive path; and

a magnetic circuit to drive the blade, comprising:

a magnet fixed with the base, and

a fine pattern coil installed at a position facing the magnet and formed directly on the blade and comprising a track pattern coil, a focus pattern coil, and a tilt pattern coil, independently driven by current supplied through the suspensions;

wherein the fine pattern coil comprises first and second fine pattern coil layers which are electrically insulated from each other; and

wherein the first fine pattern coil layer comprises the track pattern coil and the focus pattern coil and the second fine pattern coil layer comprises the track pattern coil and the tilt pattern coil.

17. The optical pickup actuator of claim **16**, wherein the base is installed to be movable in a radial direction of an optical recording medium and comprises a holder to support an end of the suspensions, such that as the blade is operated by a driving force through the magnetic circuit, the objective lens is independently driving in a track direction, a focus direction and a tilt direction.

18. The optical pickup actuator of claim **16**, wherein the magnet comprises first and second magnets arranged to face each other with respect to the fine pattern coil interposed therebetween.

19. The optical pickup actuator of claim **16**, further comprises a yoke which fixes the magnet to the base and forms a magnetic path.

20. The optical pickup actuator of claim **17**, wherein the magnet is 4-pole magnetized and surface divided such that the magnet is of a 2×2 format and is sectioned in a cross type along a first polarization line parallel to a focus driving direction of the blade and a second polarization line parallel to the track direction of the blade.

21. The optical pickup actuator of claim **20**, wherein the magnet comprises first, second, third and fourth magnet portions respectively arranged in first, second, third and fourth quadrants such that adjacent magnet portions are polarized to have opposite poles.

22. The optical pickup actuator of claim **21**, wherein the first, second, third and fourth magnet portions are formed without an interval space therebetween.

23. The optical pickup actuator of claim **17**, wherein the magnet comprises two magnets each of which is 2-pole magnetized and surface divided.

24. The optical pickup actuator of claim **23**, wherein the magnet comprises first, second, third and fourth magnet portions, wherein the first and second magnet portions are arranged close to each other and magnetic poles thereof are polarized to be opposite to each other with respect to a first polarization line which is parallel to a focus driving direction of the blade, and the third and fourth magnet portions are arranged close to each other and the magnetic poles thereof are polarized to be opposite to each other with respect to the first polarization line.

25. The optical pickup actuator of claim **24**, wherein the third and fourth magnet portions are respectively separated a predetermined distance from the first and second magnet portions in the focus driving direction of the blade.

26. The optical pickup actuator of claim **25**, wherein the first and fourth magnet portions have opposite magnetic poles while the second and third magnetic portions having opposite magnetic poles.

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